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Application of semi-distributed hydrological model to simulate the lake volumes of small closed lakes in the Northern Kazakhstan

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Burabay National Nature Park (BNNP), which is famous for its beautiful lakes and pine forests, is an important tourist destination and biodiversity hot spot in cold, semi-arid Northern Kazakhstan, Central Asia. BNNP lake system is being influenced by increasing anthropogenic pressures and climate change impacts. Lake level declines observed from 2008 to 2013 followed by rebound from 2013 onwards raised concerns about the future of these unique lakes. Previous studies on BNNP lakes showed that its steady long-term water storage decline was mainly due to a natural water balance deficit, with evaporation (from the lakes and catchments) exceeding precipitation. Next, to obtain a deeper understanding of this complex lake system, we studied the BNNP's catchments by applying a hydrological model. This work is the first attempt to simulate the hydrological processes in two key BNNP lakes (Ulken Shabakty and Burabay) using a semi-distributed hydrological model, Soil and Water Assessment Tool (SWAT). The available daily lake level measurements were transformed into lake volumes using the data from a recent bathymetric survey and Surface Volume tool of ArcGIS. The level of Burabay Lake is determined by its main outlet, Gromotukha river, that discharges the excess water from Burabay Lake to Ulken Shabakty. Therefore, it acts as a natural reservoir and allows to use the Reservoir function of SWAT. Calibration of the model by lake volumes was done for years 2010-2013 and the model performed well for both lakes (NSE 0.71 and 0.57; KGE 0.77 and 0.73; PBIAS -0.9 and -0.4 for Ulken Shabakty and Burabay, respectively). However, during validation for years 2014-2016 the model performance decreased considerably (NSE -23.94 and -0.35, KGE 0.12 and -0.35, PBIAS 7.6 and -0.3 for Ulken Shabakty and Burabay, respectively). SWAT substantially overestimated the lake volumes for Ulken Shabakty by 0.01 km^3 on average for the validation period. This extreme overestimation highlights the specific features of both basins, which has to do with the local subsurface flows. Due to the relatively simplistic representation of groundwater in SWAT and the absence of comprehensive groundwater data, the calibrated model might not have been able to fully capture the complexity of the actual hydrogeologic system. As a result, smaller in size surface catchment

boundary (in the case of Ulken Shabakty Lake) is considered in comparison to potentially larger groundwater catchment boundary. In addition, two years (2010 and 2012) used for calibration were drought years, during which the model might have compensated for the lower groundwater flows by simulating enhanced surface runoff and lateral flow. As a result, during the following years with normal and higher precipitation amounts (2013-2016) significantly higher surface runoff was generated. Further studies using coupled groundwater and surface water models are necessary to understand the interactions between groundwater and surface water.